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Federal Communications Commission
Office of the Secretary

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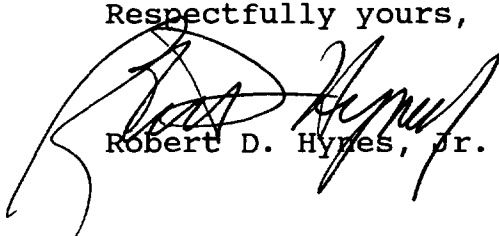
Ms. Donna Searcy
Secretary
Federal Communications Commission
1919 M Street, N.W.
Room 222
Washington, D.C. 20554

Re: Ex Parte Presentation in MM Docket No. 87-268

Dear Ms. Searcy:

At meetings today with the Commission officials listed below and members of their staffs, Dr. James E. Carnes, President and Chief Operating Officer of David Sarnoff Research Center; Dr. J. Peter Bingham, President, Philips Laboratories and NBC executive Michael Sherlock, President Operations and Technical Services along with the undersigned presented the attached material relevant to this proceeding. The matters discussed by the executives at the meetings are contained in this material or in the NBC comments previously filed herein.

Respectfully yours,


Robert D. Hynes, Jr.

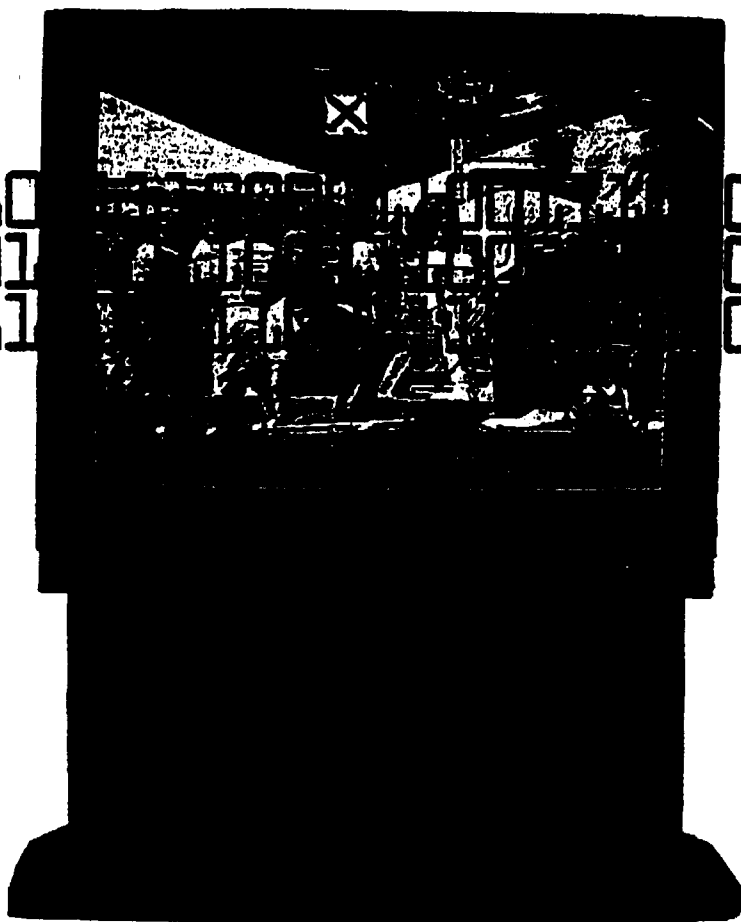
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DIGITAL VIDEO

Television, communications, and computer specialists are working to unsnarl the exchange of material in any video format



Seated at his home entertainment workstation, Mike Multimedia is researching a report on high-speed rail transportation. In a window on the display he calls up a full-motion color video sequence of a French Train à

Grand Vitesse, which he had recorded earlier on a digital laserdisc from a high-definition TV network broadcast. The scenes lack the specific detail he's interested in, so he accesses the international databank in Chicago that stores high-speed rail digital video, and requests additional color sequences. They appear immediately in a second window of the display, but as he is reviewing them, the phone rings and an image of his wife appears in a third window. Her face is flushed, and she is obviously upset. "Honey, I've had an accident with the car, but I'm not hurt," she says, "but I'm afraid we're going to need a new right front fender." Mike answers, "Don't worry about it, as long as you're O.K." Mike, his train of thought broken, is tempted to look in on a football game in a fourth window. After a few minutes, he switches to a full-screen display, and then guiltily goes back to his report. The phone rings again and a fax message from a source appears in another window, containing information to include in the report.

Visionary? Perhaps for now. But video compression, optical-fiber networks, digital recording, digital high-definition television, and the like—the technologies needed for such a scenario—are already in hand. Stirred by an explosion of digital imaging and com-

Ronald K. Jurgen Contributing Editor

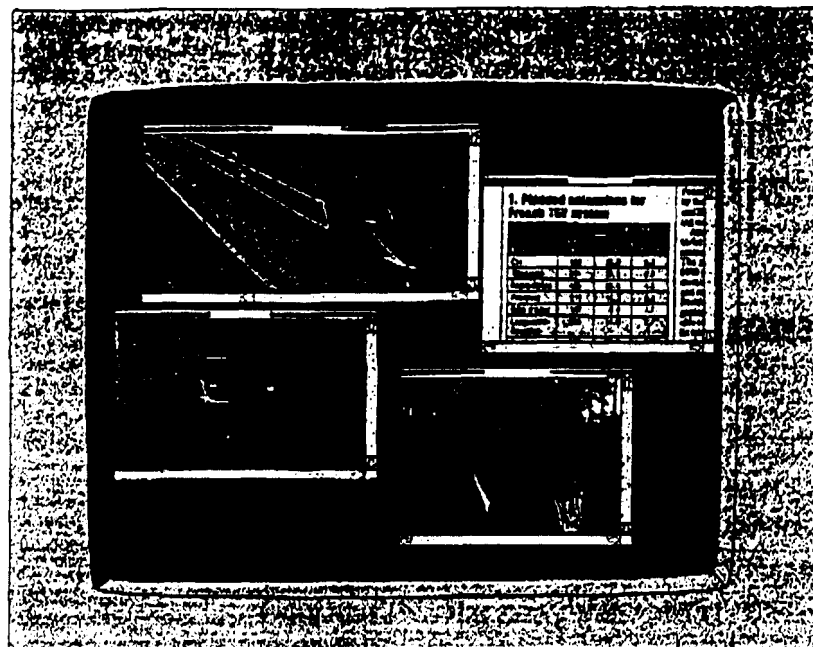
munications advances within just the past few years, those involved in TV production, broadcasting, cable, computer graphics and workstations, telecommunications, consumer electronics, you name it, are lining up to make reality serve their dreams.

November 1990 saw one of the first meetings organized so that engineers from various disciplines could debate how best to piece together the emerging world of digital imagery. The sponsors were the Advanced Television Systems Committee and IEEE-USA's Committee on Communications and Information Policy, and the venue was Washington, D.C.

COORDINATION AND HARMONIZATION. The Digital Systems Information Exchange, as it was called, explored digital developments, looked for areas of actual or potential commonality, and examined possible common frameworks for manipulating digital images "at various levels of performance, for a variety of applications, and in a fashion that takes best advantage of current and future developments in television, computers, and communications technologies." So said K.P. Davies, director of standards and technology for the Canadian Broadcasting Corp., Montreal, in his keynote address. Davies emphasized that by now application-dependent developments of digital imaging require "coordination and harmonization if a future coherence is to be achieved."

Gary Demos of DemoGrafX in Culver City, Calif., another participant, also found harmonization desirable in light of the growing use of moving TV imagery on computer screens. Both live analog and compressed digital TV signals in various formats are being applied, he said, in such areas as medical imaging, military applications, aviation and flight control simulation, computer graphics, computer-aided design and engineering, aesthetic styling, and motion picture production.

Demos accordingly stressed the need to design an architecture for high-definition



A futuristic advertisement display could exhibit in windows, as simulated here, full-motion or still video from a variety of video formats.

television (HDTV) and high-resolution imaging (HRI) systems that would be scalable, extensible, and open. Scalability he defined as the ability to use a variety of resolutions, temporal rates, colorimetry, and intensity dynamic ranges. In other words, displays designed for one set of those parameters should be able to do a reasonable job of showing images produced at higher or lower values of resolutions, rates, color, and so forth.

Extensibility, according to Demos, referred to the ability of a framework of display formats or standards to embrace new requirements and applications. And an open architecture would support inputs and dis-

play parameters with many formats. (Extensibility and open architecture are discussed in some detail in the last article of this special report, p. 28.)

Two further Digital Systems Information Exchange meetings were held in March and September 1991, the latter with the sponsorship of the Society of Motion Picture and Television Engineers (SMPTE) instead of the Advanced Television Systems Committee. By then, the committee's start-up function had become a standards function led by the society, which is based in White Plains, N.Y.

SMPTE's involvement was prompted by the keynote address at the March session. Michael J. Sherlock, president, operations and technical services, National Broadcasting Co. (NBC), New York City, challenged those attending with these words: "We need to find practical solutions. We need agreement on how information can be used to reconstruct images in a form which fits the requirements of the different businesses we are in."

Stanley N. Baron, managing director of technical development, NBC, and then SMPTE engineering vice president, responded by saying that SMPTE would investigate two areas: a protocol for a digital interface header/descriptor to permit digitized images to cross industry and standards boundaries, and a possible hierarchy of standards that would mesh industries' varying display requirements. It was further agreed that the research should be conducted within

Defining terms

CD-ROM XA: a compact-disc ROM extended architecture that specifies an encoding format (adaptive differential pulse code modulation) for storing audio information in a digital format.

CDTV: Commodore Dynamic Total Vision, a multimedia system.

Convertibility: capability of being converted to and from existing standards.

Discrete cosine transform: a form of coding used in most of the current image compression systems to reduce the number of bits that must be transmitted.

Extensibility: the capability of being extended to higher performance.

Huffman coding: a static set of minimum-redundancy integral-length bit strings.

Lossless compression: a means of compressing video data that ensures the data is exactly recoverable with no loss in image quality.

Multimedia: descriptive of the delivery of information that combines different content formats (motion video, audio, still images, graphics, animation, text, and so on).

RGB: red-green-blue. A type of computer color display output signal composed of separately controllable red, green, and blue signals, as opposed to composite video in which signals are combined prior to output.

Scalability: the capability of being placed in a graduated series of performance or resolution parameters.

YUV color system: a color-encoding scheme for natural pictures in which the luminance (Y) and chrominance (UV) are separate.

the standards activities of SMPTE.

With a standardized or universal header/descriptor, any video stream could be recognized by any device, whether a TV receiver, computer, or workstation. One segment of the descriptor would identify the type of video that had been received. If the receiving device contained the right kind of decoders, it could then display the received video. Other parts of the descriptor would specify the size of the data packet and might also include such information as copyright information and decoding algorithms.

The SMPTE Task Force on Headers/De-

scriptors investigated such factors as the header kernel, appropriate error-correcting codes, and block-length specification, and on Jan. 3 recommended a common protocol to the SMPTE Standards Committee for consideration at its meeting on Feb. 6. The SMPTE Task Force on Digital Image Architecture was still, at this writing, weighing an open system scalable to various performance levels and extensible to new technologies and had not yet recommended a structure for a hierarchy of digital standards to facilitate interoperation of high-resolution display systems.

The work on header/descriptors and digital image architecture, when finalized in standards, will expedite the development of products capable of exploiting to the fullest extent the various video formats. In the meantime, the existing standards or drafts of standards are also aiding the cause of interoperability.

There are products now available that perform some of the functions necessary for interoperability. Many of them are based on the standards described in the next section. Selected products are described in the final section.

SPECIAL REPORT / CONSUMER ELECTRONICS

An abundance of video formats

Achieving a universal descriptor and an interformat exchange structure are crucial to the promise of digital imaging

Even as the Digital Systems Information Exchange meetings were being held and task forces from the Society of Motion Picture and Television Engineers (SMPTE) began their work on headers/descriptors and digital image architecture, progress was being made on digital video standards. The three main ones concern still-picture compression, video teleconferencing, and full-motion compression on digital storage media. They have been proposed by the Joint Photographic Experts Group (JPEG), the International Telegraph and Telephone Consultative Committee (CCITT), and the Moving Picture Experts Group (MPEG), respectively. All are lossy techniques.

The JPEG standard is an algorithm for coding still pictures developed under the auspices of the International Organization for Standardization (ISO). CCITT's Recommendation H.261 (also called p×64) specifies a method of communication for visual telephony. Both were described in some detail in the October issue of *IEEE Spectrum* (see To probe further, p. 30).

JPEG is a general-purpose compression standard designed to meet the needs of continuous-tone, still-image applications. It is applicable to such uses as photovideotex, desktop publishing, the graphic arts, color facsimile, newspaper wirephoto transmission, and medical imaging.

Recommendation H.261 (p×64) is a stan-

dard for covering the entire channel capacity of the integrated-services digital network (ISDN). The p×64 designation refers to $p \times 64$ kb/s, where p can have any value from 1 to 30. The standard is intended for use in videophone and videoconferencing. If p equals 1 or 2 (due to severely limited available bit rate), only videophone is appropriate. But if p is equal to 6 or more, the available bit rate is higher and more complex pictures can be transmitted.

MPEG FOR FULL-MOTION VIDEO. MPEG, the third digital video standard, can be applied to such storage media as compact-disc ROM (CD ROM), digital audio tape, Winchester disk, and writable optical discs and on such communication channels as ISDN and local-area networks (LANs). MPEG addresses the compression of video signals at about 1.5 Mb/s and of a digital audio signal at the rates of 64, 128, and 192 kb/s per channel. It also deals with the synchronization and multiplexing of multiple compressed audio and

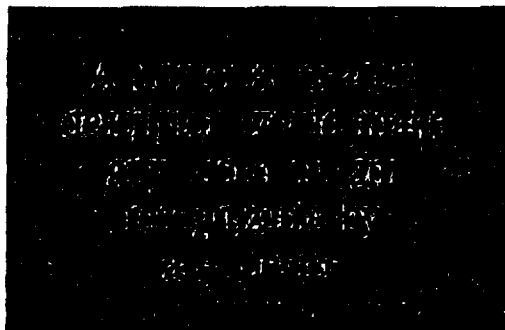
IEEE's Consumer Electronics Society.

To reduce temporal redundancy, Le Gall said, the standard relies on block-based motion compensation, while to reduce spatial redundancy, it relies on transform-based compression. Motion compensation is based on both pure predictive and interpolative codings. Motion information is based on 16-by-16 blocks, is compressed by using variable-length codes for maximum efficiency, and is transmitted along with the spatial information. The variable-length coding takes advantage of the strong spatial redundancy of the motion vector field and is applied to further compress the results of the discrete cosine transform (DCT) and to reduce the impact of the motion information on the total bit rate. Only those codes with a fairly high probability of occurrence are coded with a variable-length code.

Since the DCT decorrelates the data, its output after quantization is likely to have long runs of zeros. These can be efficiently encoded by a run-length encoder, which simply gives the number of consecutive zeros before a non-zero number. Run-length coding gives a significant degree of compression.

Le Gall said that three types of pictures are considered in MPEG: intrapictures (I frames) that provide access points for random access with moderate compression; predicted pictures (P frames) that are coded with reference to a past picture and are used as a reference for future predicted pictures; and interpolated or bidirectional pictures (B frames) that require both a past and a future reference for prediction. Clearly the three picture types are related (Fig. 1).

MPEG exploits the temporal redundancy of video signals through motion-compensated prediction. The assumption here is that the blocks of the current picture can be modeled as a translation of blocks of some previous picture. Also used is motion-compensated interpolation, which adds a



video bit streams.

The MPEG standard is generic, that is, it is independent of any one application, said Didier Le Gall, director of research at C-Cube Microsystems, San Jose, Calif., at the Third Annual Electronic Industries Association Digital Video Workshop. The meeting was held in Arlington, Va., in October by the Electronic Industries Association, Washington, D.C., with the participation of the

correction term to a combination of a past and future picture reference. Motion-compensated interpolation makes possible a high degree of compression.

To reduce spatial redundancy, MPEG uses DCT coding, as in JPEG and H.261. DCT transforms a block of pixel intensities into a block of frequency transform coefficients. The transform is applied in turn to new blocks until the entire image has been transformed. At the decoder in the receiver, the inverse transformation is applied to recover the original image.

MPEG also uses visually weighted quantization—that is, coarser quantizers can be used for the higher frequencies because subjective perception of quantization error varies greatly with frequency. According to Le Gall, the exact quantization matrix used depends on parameters such as the characteristics of the intended display, the viewing distance, and the amount of noise in the source.

The MPEG standard specifies a layered structure, syntax, and bit stream for video on digital storage media. The layered structure separates entities in the bit stream that are logically distinct. The syntax provides for application-specific features without penalizing applications that do not need those features.

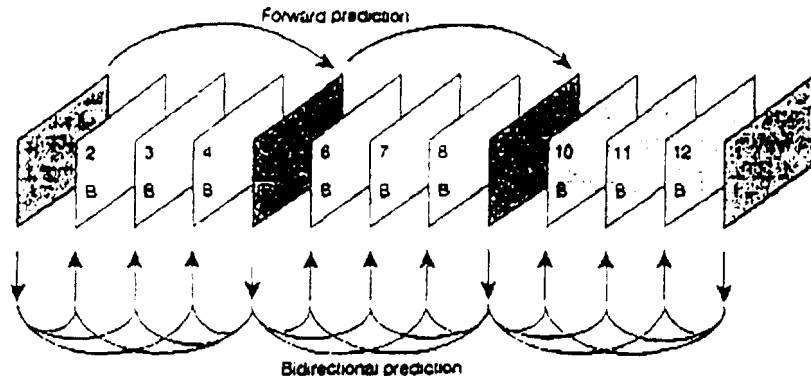
An example of bit-stream customization given by Le Gall involved providing random access to, and the ability to edit, video stored on a computer hard disk. He explained that such operations would require many access points. Groups of pictures would be coded with a fixed number of bits to make editing possible.

The MPEG syntax contains six layers, each of which supports functions such as DCT, motion compensation, resynchronization, and random access point. The syntax also defines the bit stream, which is characterized by two fields: bit rate and buffer size. The latter specifies the minimum buffer size necessary to decode the bit stream within the context of the video buffer verifier. It is an abstract model of decoding used to verify that an MPEG bit stream can be decoded with reasonable buffering and delay requirements.

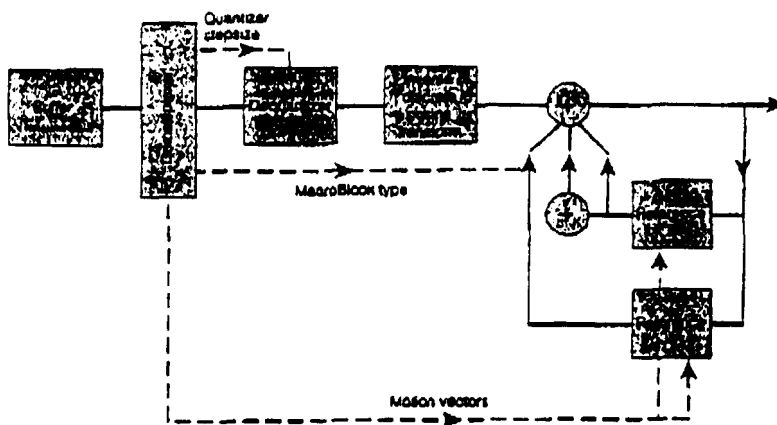
Le Gall explained that encoders and decoders are not specified *per se* in the proposed MPEG standard. In other words, an encoder is an MPEG encoder if it can produce a legal MPEG bit stream, and a decoder is an MPEG decoder if it decodes an MPEG bit stream satisfactorily [Fig. 2]. The standard defines only the bit-stream syntax and the decoding process. This allows for enhancements in encoder performance as technology advances.

A new phase of MPEG committee activities is addressing the need for a video compression algorithm for higher-resolution signals at bit rates up to 10 Mb/s.

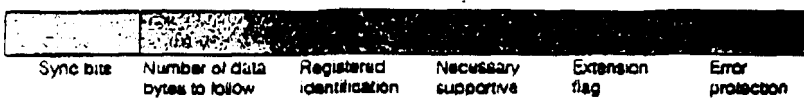
OTHER VIDEO FORMATS. In addition to JPEG, H.261, and MPEG, a number of video formats must be taken into account when con-



[1] Display order for frame groups for MPEG—one of three main digital video standards—consists of interframe coding based on intrapictures (I), predicted pictures (P), and interpolated, bidirectional prediction (B). Here an intrapicture is inserted after every 11 frames and the ratio of interpolated pictures to intra- or predicted pictures is three to one. Organization of the pictures is flexible and depends upon such parameters as coding delay.



[2] A typical MPEG decoder would contain a receiving buffer for the coded bit stream used to verify that an MPEG bit stream is decodable with a reasonable buffering and delay requirement. The bit stream is demultiplexed into overhead information (motion information, quantizer stepsize, macroblock type, and quantized digital cosine transform, or DCT, coefficients). The DCT coefficients are dequantized and fed to an inverse DCT unit. A reconstructed waveform from the IDCT is added to the result of the prediction. Two reference pictures are used to form the predictor.



[3] A basic header/descriptor system for enabling recognition of a digital video signal consists of header identification and length, service identification, any supporting data needed, an extension flag to indicate if additional blocks of data should be accessed, and error protection.

sidering the problem of system interoperability. They include the analog television formats of NTSC, PAL (phase alternating line), and Secam (sequential color and memory), the digital formats of proposed HDTV broadcast systems for the United States, and proprietary multimedia digital video formats. The last-named include Digital Video Interactive (DVI) from Intel, Compact Disc Interactive (CD-I) from Philips Consumer Electronics, CDTV from Commodore Electronics, and PhotoCD from Kodak.

For the family of multimedia products

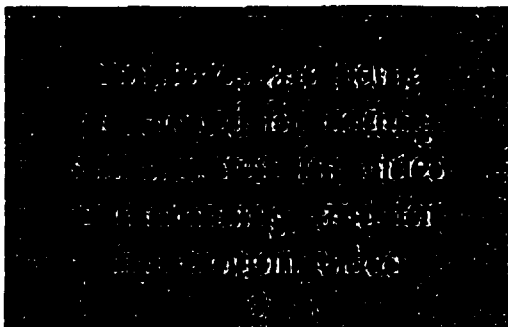
coming on the market, the Interactive Multimedia Association (IMA), based in Washington, D.C., has been active in promoting industrywide compatibility. In the fall of 1988, it formed the IMA Compatibility Committee to develop recommendations for multimedia applications that would permit their portability across a variety of hardware-software platforms. The committee has focused first on interactive video applications in the MS-DOS environment, but plans later to study other operating systems and multimedia technologies.

A first draft of recommended practices was produced in August 1989 and a revised draft in February 1990. The final document, "Recommended Practices for Multimedia Portability," Release R 1.1, was published in October 1990. Among its recommendations are commands for general system services, visual management, videodisc players, and X-Y-input devices. The recommended practices furnish platform independence but not device interoperability (plug-and-play). (Device interoperability requires classes of related devices to furnish functionally identical services at the component level.)

Platform independence lets applications run unchanged on any platform based on the same general class of host computers. They can do so only if the different hardware and software platforms show consistent behavior at the application-interface level. Furnishing that consistency is the goal of the interface and command definitions.

In November 1990, the U.S. Department of Defense (DOD), Washington, D.C., incorporated the IMA specification in Military Standard 1379 Appendix D. On March 14 last year, the DOD issued an instruction (1322.20) entitled "Development and Management of Interactive Courseware." That instruction mandates that all interactive multimedia courseware and hardware systems purchased by the DOD must comply with the IMA specifications. And the IMA has coordinated its compatibility efforts with the National Institute of Standards and Technology (NIST), Gaithersburg, Md.

The efforts being put into standards like JPEG, H.261, and MPEG, and the work on multimedia platform interoperability go far to make digital video more generally usable. But before digital video interchange can become widely possible, a standardized header/descriptor and a reference structure for interformat exchanges are essential. They



would enable the recognition of any video signal so that the receiving device could display it—if that device had the necessary decoding circuits.

At this writing, the SMPTE draft standards for the two elements were not yet available. But *Spectrum* did talk about them with NBC's Stanley N. Baron. Baron told us that the SMPTE header/descriptor standard would define a single digital transport protocol for all services, each of which would be uniquely identified within the context of the protocol. A key feature of the protocol, he said, is that it permits the bypassing of any data blocks pertaining to services "for which there is no interest, for which access

is denied, or which are not defined in the receiver in question."

Baron cited key functions of the header and descriptor. The header would:

- Identify by a registered number the encoded standard used by the attached block of data.
- Specify the length of that block of data so that data could be bypassed as described previously.
- Indicate whether a descriptor—an extension of the header—follows the header.
- Permit users to intercept data streams randomly and identify services quickly.

The descriptor's chief function is to add information to improve the usefulness of the data to the user. It also provides a means of self identification and error protection [Fig. 3].

Baron gave us an example of how the header/descriptor might be used with the proposed digital HDTV transmission systems for a U.S. terrestrial standard. A header identification number could be assigned to the video data blocks, another could describe the type of audio (monophonic, stereo), and a third the program or program source identification (or the program identifier could contain the bits necessary to identify the audio service).

Using this scheme, Baron told us, the entire basic service could be defined in a data service requiring as little as less than 20 bytes of data per video frame, or 4800 kb/s. But by providing for extensions, the system could be expanded to accommodate the service needs of the local community.

SPECIAL REPORT / CONSUMER ELECTRONICS

Putting the standards to work

Personal computers, compact-disc players, and multimedia systems are some of the products using standard video formats

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any of the proposed video format standards are not yet official. All the same, products under development are being based on them—as well as on the formats that have been officially approved.

Among the many users of the JPEG standard is NeXT Computer Inc., Redwood City, Calif. NeXTstep, the standard operating environment on NeXT computers, includes support for the JPEG draft in its 2.0 version. All applications that use the NXImage class

can read JPEG-compressed tag image file format (TIFF) files. The decompression and imaging of a 24-bit 640-by-480-pixel image takes less than 10 seconds on a NeXT computer equipped with a Motorola 68040 processor.

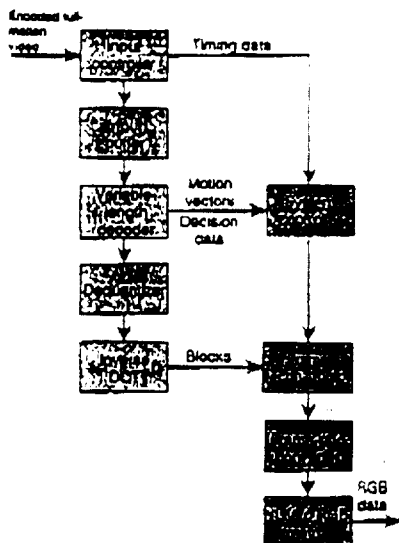
The i750 video processor, used in the DVI multimedia system from Intel Corp., Princeton, N.J., can process images encoded with

the JPEG draft standard. It can decode a 640-by-480 JPEG-encoded image in less than one second. Intel is now developing a chip that will handle MPEG decoding for introduction later this year.

CD-I TO GO MPEG. A good example of the trend to full-motion video in multimedia products is the Philips Imagination Machine, a CD-I home entertainment system that

Some network protocols and their bit-rate regimes

Service	Bit-rate regime
Conventional telephone	0.5-56 kb/s
Fundamental bandwidth unit of telephone company (DS-0)	56 kb/s
Integrated-services digital network (ISDN)	64-144 kb/s
Personal computer local-area network	30 kb/s
T-1 (multiple of DS-0)	1.5 Mb/s
Ethernet (packet-based local-area network)	10 Mb/s
T-3 (multiple of DS-0)	45 Mb/s
Fiber-optic ring-based network	100-200 Mb/s



[4] Philips Research Laboratories designed this Compact Disc Interactive (CD-I) decoder for full-motion video. Once the video is decoded from luminance and chrominance (YUV) data and converted to red-green-blue (RGB) data, it can be shown as a partial-screen display together with other video partial-screen displays.

combines CD-quality audio with video, text, graphics, animation, and interactive capabilities. The product debuted in New York City on Oct. 16. The CD player is connected to any TV receiver and stereo system. A standard 5-inch CD-I disc is loaded in the same way as a CD-Audio disc and is controlled by a remote control thumbstick.

Users direct the action on the TV screen, activating selected areas by pointing to and clicking on command areas on the screen (noted with symbols or words). The user may also interrupt a program while it is running, whether to recall a certain choice, go back to a previous step, ask for more detailed information, or request information in another language.

The Magnavox CD1910 player was developed to a worldwide CD-I standard to ensure compatibility with all CD-I discs developed, regardless of make, manufacturer, or country of origin. The player will also play 3-inch and 5-inch CD-Digital Audio discs, CD+Graphics discs and visuals, CD ROM-XA "bridge" discs, and Photo CD discs.

The current player has still picture and animated video capabilities but not full-motion video. But an MPEG-based full-motion video module will be available from Philips later this year and will plug into a socket already in place on the back of the CD-I player chassis.

An input controller in the decoder (Fig. 4) receives the encoded full-motion video bit stream and stores it in a buffer. The controller also extracts timing data—used to synchronize video with other functions, such

as audio, and to ensure that real-time demands from the bit stream are obeyed—and sends that data to the system controller. The output from the buffer is processed by a variable-length decoder, which recovers motion vectors, decision data, and quantized blocks from the encoded bit stream and passes them to the system controller. The quantized blocks are also dequantized and transformed by an inverse discrete cosine transform.

The 8-by-8 luminance or chrominance blocks that are the transform's output go to a frame reconstructor, which processes them, together with the motion vectors and decision data, to reproduce the frames. Reconstructed frames are available with a frame rate of 24, 25, or 30 Hz. The rate depends on the frequency of the coded video after subsampling. The YUV representation of the frames—the specific representation of luminance and chrominance used in the encoder and decoder—is transformed to an RGB representation, which can then be displayed on a portion of the screen.

Last April Philips Consumer Electronics Co., Knoxville, Tenn., and Motorola Inc., Schaumburg, Ill., announced plans to cooperate in developing chips for CD-I and MPEG. Philips subsequently announced its cooperation with C-Cube Microsystems Inc. to develop real-time compression chips.

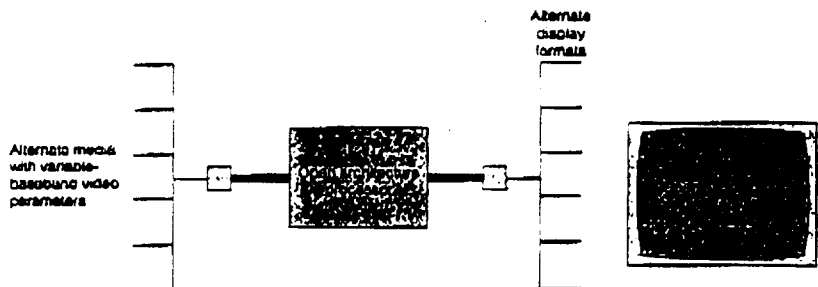
With full-motion video capability, a CD-I disc could conceivably be used for full-length movies that would be displayed on the full screen. In that event, the CD-I discs would compete with laser discs.

PHOTO CD SYSTEM. Philips has also worked with Eastman Kodak Co., Rochester, N.Y., on new features for the Kodak Photo CD system announced in September 1990. The

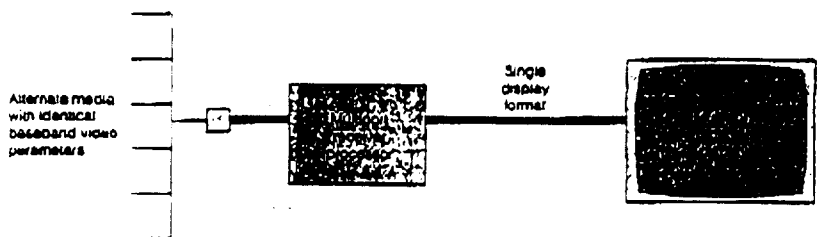
idea behind the system is to enable consumers to have their 35-mm negatives or slides inexpensively scanned and digitized by photofinishers for storage on Photo CD discs. These discs, which hold up to 100 images of photographic quality, may be loaded on a personal computer with a CD-ROM drive. With Photo CD software, available in the Photo CD Access developer toolkit, the stored images may be modified, manipulated, and exported for use in such applications as word processing, desktop publishing, and painting and drawing packages.

Announced by Kodak and Philips at the Consumer Electronics Show in Las Vegas, Nev., in January was the news that sound, text, and graphics can now be recorded with the photographic images onto the Photo CD discs. The discs with interactive playback capabilities will be playable on TV receivers with dedicated Photo CD players (to be available this summer), on CD-I players, and on computers with CD-ROM XA (extended architecture) drives. Pre-recorded discs carry up to 800 images, digitally recorded at TV resolution, or up to 72 minutes of full CD audio sound, or any combination thereof. Disc users will control their viewing of the contents through a simple infrared remote control device. The player also plays standard CD audio discs. A Huffman encoding process was used to obtain lossless compression after quantization of the high-frequency residual images.

MPEG FOR HDTV, TOO. At least one of the proposed U.S. digital HDTV terrestrial transmission formats ["The challenges of digital HDTV," *IEEE Spectrum*, April 1991, pp. 28-30, 71-73] uses a video compression technique based on MPEG. The Advanced Digital Television (ADTV) entry from the

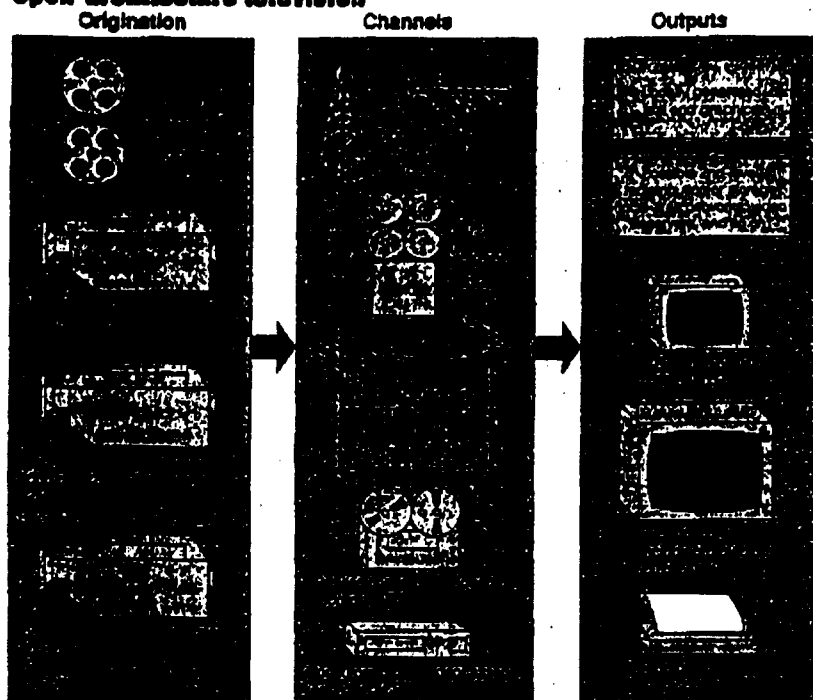


[5] An open-architecture receiver can handle media employing variable-baseband video parameters and produce displays in a variety of formats.



[6] A multiport receiver handles media with like-baseband video parameters and uses a single display format.

Open-architecture television



[7] An open-architecture TV receiver decouples the numerical parameters of origination, channel, and output of video images.

Advanced Television Research Consortium—NBC, David Sarnoff Research Center, Philips Consumer Electronics, Thomson Consumer Electronics, and Compression Labs Inc.—incorporates MPEG++ that upgrades the MPEG compression approach to HDTV pictures at 20 Mb/s.

OPEN OR MULTIPORT RECEIVERS? Even given a standard header/descriptor to identify an incoming bit stream of coded video data, the receiving device will not be able to display the video unless it can decode that particular bit stream. With the proliferation of video formats, this presents a problem. Whereas it might be relatively easy to design TV receivers that could decode NTSC, PAL, and Secam signals (if costs were no problem), it would be very much more difficult to design a receiver that could decode every video format.

By and large, "all-purpose" receivers could have either an open architecture (Fig 5) or a multiport design (Fig. 6). Arpad G. Toth, then chief scientist, Philips Laboratories, Briarcliff Manor, N.Y., and now with Eastman Kodak Co., described both at the first Digital Systems Information Exchange meeting in November 1990.

The open-architecture receiver, he said, would support multiformat emission and display parameters. But, he cautioned, although its ability to process and monitor digital multiresolution video could be a potential asset for the workstation and personal computer, it would present a problem for TV receiving systems. They may require simpler and minimum-cost design rules—hence

the generation of the multiport receiver concept.

A multiport receiver could be viewed as a special case of an open-architecture receiver, Toth said. "The input and output interfaces of the receiver would allow maximum user flexibility for interconnection without any signal degradation," he explained.

Development of architecture and interface standards for the multiport receiver in both analog and digital video applications, he reported, was well under way within the Electronic Industries Association, Washington, D.C.

The significance of open architecture and scalability was discussed by V. Michael Bove Jr. and Andrew B. Lippman of the Massachusetts Institute of Technology's Media Laboratory, Cambridge, in the January 1992 issue of the *SMPTE Journal*. They said that open architecture hinged on an intermediate representation for video signals, one that "does not have a fixed sampling raster or frame rate, and which can exist at a range of bandwidths."

They described work at the MIT Media Laboratory on applying the open-architecture concept to the entire television system (Fig. 7). The goals are to maximize the interconnection options and to permit production, distribution, storage, and viewing to employ a variety of standards optimized for specific situations.

An open-architecture video representation is scalable in resolution, they emphasized. In other words, the number of lines on the display is determined strictly by the receiver

hardware and is not coupled to the number of lines used by the production equipment. Scalability means that it should not be necessary to decode the entire transmitted signal to obtain an image at lower resolution than the source. The signal is also scalable temporally, they reported, so that the frame rate of production and display are decoupled.

TO PROBE FURTHER. The April 1991 issue of the *Communications of the ACM* is a special issue on digital multimedia systems. It was published by the Association for Computing Machinery, 11 W. 42 St., New York, N.Y. 10036; 212-869-7440. This article draws on some of the material published in that issue.

Descriptions of the JPEG and H.261 coding algorithms are contained in the article, "Video compression makes big gains," by Peng H. Ang, Peter A. Ruetz, and David Auld, in the October 1991 issue of *IEEE Spectrum*, pp. 16-19.

For detailed information on Intel Corp.'s Digital Video Interactive (DVI) technology, see *Digital Video in the PC Environment*, second edition, by Arch C. Luther (McGraw-Hill, New York, 1991) and "Multimedia Applications Development Using DVI Technology," by Mark J. Bunzel and Sandra K. Morris (McGraw-Hill, New York, 1992).

An interim report of the FCC Advisory Committee on Advanced Television Systems recommends that the header/descriptor notion be adopted by the FCC. For a copy, contact Robert Sanderson, Eastman Kodak Co., Rochester, N.Y.; 716-253-6362.

For an update on multiport receiver developments, contact the Electronic Industries Association, 2001 Pennsylvania Ave., N.W., Washington, D.C. 20006-1813.

The February 1992 issue of the *IEEE Transactions on Consumer Electronics* contains three papers from the Digital Video Workshop held in October. Contact IEEE Publication Sales, 445 Hoes Lane, Box 1331, Piscataway, NJ. 08855-1131; 908-981-0060.

The Society of Motion Picture and Television Engineers (SMPTE) welcomes the participation of any individual or group that has an interest in the header/descriptor standards work. Contact Sherwin H. Becker, director of engineering, SMPTE, 595 West Hartdale Ave., White Plains, N.Y. 10607; 914-761-1100.

The January 1992 issue of the *SMPTE Journal*, pp. 2-5, contains an article "Scalable Open-Architecture Television," by V. Michael Bove Jr. and Andrew B. Lippman.

The proceedings of SMPTE's 26th Annual Advanced Television and Electronic Imaging Conference, held in San Francisco, Feb. 7-8, is available from the society. That meeting addressed the serious need for technological compatibility between television and computers.

The Interactive Multimedia Association's "Recommended Practices for Multimedia Portability," Release R 1.1, is available from the organization, 800 K St., N.W., Suite 440, Washington, D.C. 20001; 202-408-1000. ♦

TESTING

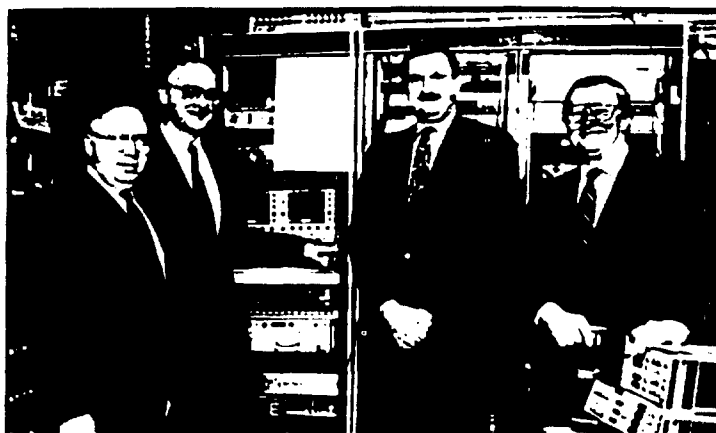
ATRC UNVEILS DIGITAL HDTV SYSTEM: PRESENTS TECHNICAL INNOVATIONS

The Advanced Television Research Consortium (ATRC) has unveiled the technical aspects of its advanced digital television transmission system and received FCC certification for testing in early April. The system includes interoperability and interference-related characteristics that will enable it to outshine competing proposals. ATRC representatives said at a news conference here last week.

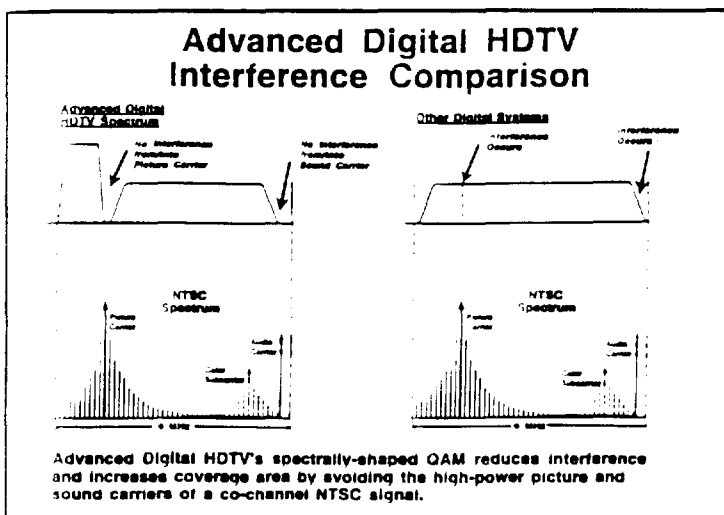
The consortium, which includes the David Sarnoff Research Center, NBC, Philips Consumer Electronics, Thomson Consumer Electronics and Compression Labs Inc., clearly has left behind its former analog, enhanced-definition television approach in favor of a digital alternative.

"We strongly believe that Advanced Digital TV is the best choice for America," said James Carnes, president of the Sarnoff Research Center. "Its creative combination of new technology, coupled with emerging standards, allows for outstanding HDTV picture and sound quality, freedom from interference and a reliable and robust broadcast signal under virtually all transmission conditions."

The system's signal design includes a "spectral notch," permitting the avoidance of NTSC interference, said Carnes. The notch permits interference-



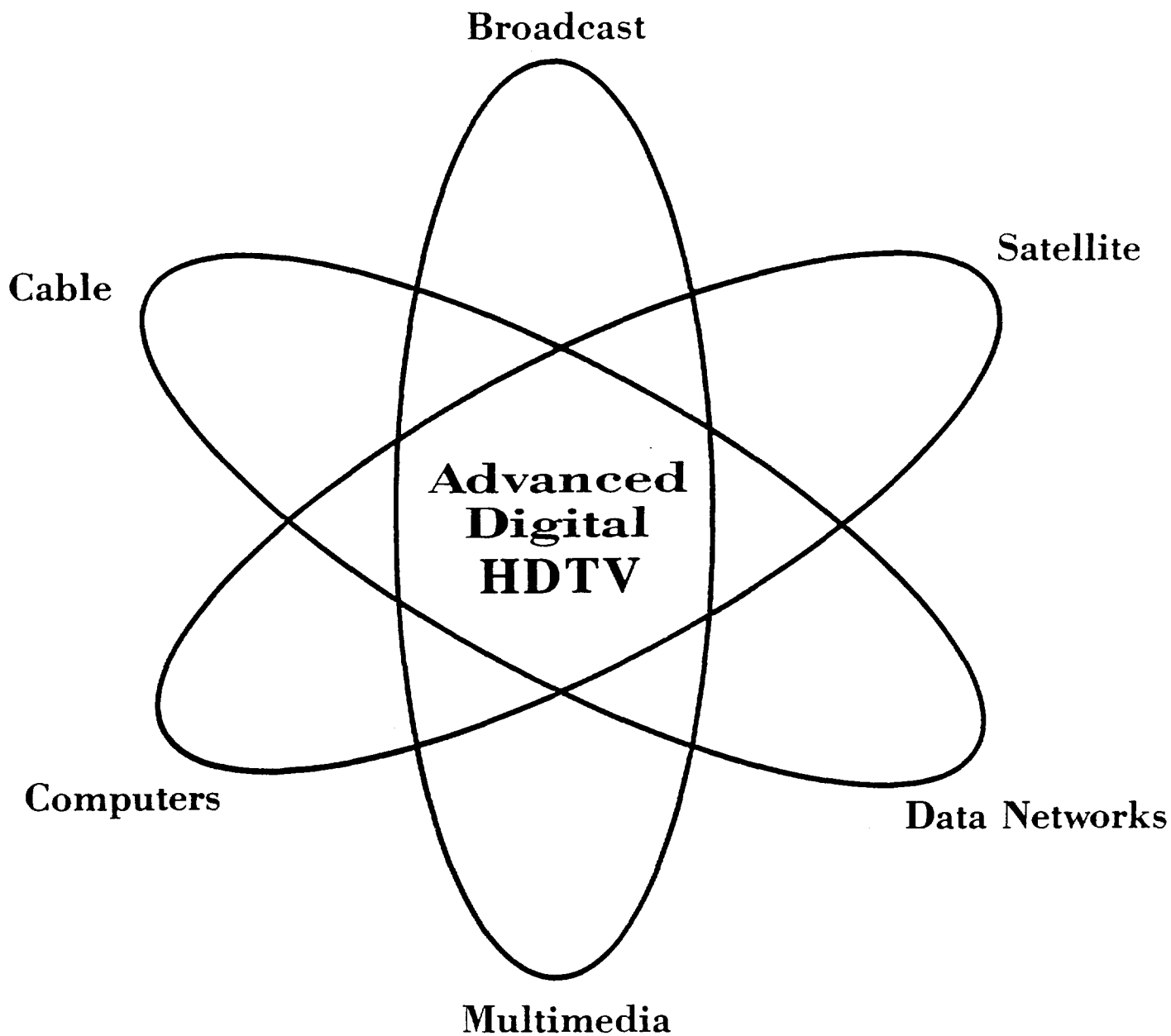
NEW DIGITAL HDTV SYSTEM PROGRESSES: Leaders of the Advanced Television Research Consortium reviewed the progress of their new Advanced Digital HDTV system being completed by the two largest television laboratories in the U.S., the David Sarnoff Research Center in Princeton, NJ and Philips Laboratories in Briarcliff, NY. Left to right: Michael J. Sharlock, President of NBC Operations and Technical Services; J. Peter Bingham, President of Philips Laboratories; James E. Carnes, President of the David Sarnoff Research Center; and D. Joseph Donahue, Senior Vice President, Technology and Business Development, Thomson Consumer Electronics.



free transmission by using portions of the spectrum isolated from NTSC signals (see graphic). Two-tiered, spectrally shaped, QAM data transmission permits the most important bits to receive higher power. Additionally, the signal operates with lower power than NTSC stations, which eliminates interference "even with co-channel separation needed to accommodate most broadcasters with a simulcast channel," the ATRC stated. The system also is innovative because of its packaging of data transmissions, said J. Peter Bingham, president

of Philips Laboratories. The system offers a data packeting capability that flexibly adapts to multimedia services, he added. Broadcasters will be able to send variable streams of video, audio and data programming to viewers. "Our data packaging will allow for new forms of educational and entertainment programming as well as extraordinary use of the home TV set," Bingham said.

Moreover, the data packaging capability is compatible with the video data compression protocols adopted by the International Standards Organization's Motion Picture Experts Group (MPEG). As a result, ATRC's transmission standard will be compatible with digital video, consumer electronics, computer and telecommunications equipment and services worldwide, Carnes said.



ADVANCED TELEVISION RESEARCH CONSORTIUM

DAVID
Sarnoff
RESEARCH CENTER
Subsidiary of SRI International



PHILIPS



THOMSON



CLI

COMPRESSION
LABS, INCORPORATED

WHY "ADVANCED DIGITAL HDTV" IS BEST FOR AMERICA

I. Introduction

- o 1992 is a key year for HDTV in America.
 - (1) Testing of several competing HDTV transmission standards will be completed this summer;
 - (2) By the fourth quarter of 1992, the FCC's Advisory Committee on Advanced Television Service (ACATS) is scheduled to recommend an HDTV system to be the official American standard for HDTV over-the-air broadcasting. Four of the five systems in the competition are digital.
 - (3) By mid-1993, the FCC will conduct a rulemaking to officially adopt the standard.
- o The Advanced Television Research Consortium has developed the most advanced digital HDTV system being considered by the FCC.

- o Our unique consortium combines the two largest video R&D labs in the United States, the two largest TV receiver manufacturers in the United States, and the leading American television network.
 - NBC
 - David Sarnoff Research Center, Princeton, NJ
 - North American Philips Corp.
 - Philips Labs, Briarcliff Manor, NY
 - Philips Consumer Electronics, Knoxville, TN
 - Thomson Consumer Electronics, Indianapolis, IN
 - Compression Labs, San Jose, CA
- o There is much more at stake than better picture quality in choosing an HDTV standard.
- o For the first time in many years, a new market for TV sets will be created. HDTV will also create a myriad of new applications throughout the electronics, telecommunications, defense and computer industries -- and in related information technologies, such as medical imaging.

The ATRC is committed to building a strong domestic HDTV industry and to ensuring that HDTV provides a valuable and lasting contribution to the U.S. economy. We believe it is essential for the government:

- To choose the best system from a technological standpoint;
and*
- To choose the system that best enhances U.S. competitive-
ness and provides the maximum number of U.S. jobs.*

II. HDTV Chronology and Future Schedule

- o In 1987, after the first U.S. demonstration of the Japanese Muse HDTV system the year before, U.S. broadcasters asked the FCC to address the HDTV issue. Congressional hearings also focused U.S. attention on HDTV. The FCC established ACATS and gave it responsibility to:
 - Organize a process for the development and implementation of HDTV in America;
 - Set a schedule for testing each proposed system for HDTV broadcast transmission;
 - Supervise laboratory testing at the industry-sponsored Advanced Television Test Center (ATTC) in Alexandria, Virginia.
 - Establish specific criteria upon which each proposed system should be evaluated;
 - Analyze the test results and submit a recommendation and supporting data to the FCC.

- o In July 1991, system testing began and is continuing today. The approximate future schedule follows:
 - Fall 1992: Testing to be completed
 - 4th quarter 1992: System recommended by ACATS
 - Early 1993: Field test verification
 - Mid-1993: FCC selects and announces standard
 - 1993-1995: Design, manufacture and installation of broadcast and cable equipment
 - 1995-96: Broadcast initiation to home
 - 1996 - : New service innovations

- o *The first key decision point will be the ACATS recommendation to the FCC scheduled for later this year.*

III. System Criteria

- o The FCC Advisory Committee is evaluating each system based on the following four sets of criteria:
 1. video and audio quality
 2. coverage area, transmission robustness, accommodation percentage
 3. interoperability characteristics, scope of services and features, extensibility
 4. cost to broadcasters, consumers and alternative media
- o The actual laboratory testing is focusing on video/audio quality and transmission robustness. The remainder of the criteria will not be determined by actual laboratory testing.
- o Beyond these criteria, there is an emerging consensus that the winning system should use digital technology -- the language of computers -- and must be able to be broadcast at the same time over a second channel (simulcast) as today's NTSC analog transmissions without interference.

- o Digital is state-of-the-art technology, and the FCC's emphasis on digital is to be commended. Digital video will have enormous new applications for consumer electronics, for the defense and computer industries, for educational TV and more.
- o Japan and the Europeans are developing a satellite HDTV system based on analog technology.

IV. System Proponents

- o When the competition began, there were more than 20 HDTV system proponents. Today, only four major HDTV system proponents remain:
 1. ATRC - Advanced Television Research Consortium (digital proposal)
David Sarnoff Research Center
Philips Consumer Electronics and Philips Laboratories
Thomson Consumer Electronics
NBC television network
Compression Labs
 2. Zenith/ATT/Scientific Atlanta (digital proposal)
 3. General Instrument/MIT (2 digital proposals)
 4. NHK (analog proposal)
- o Lengthy descriptions of each proponent's system were submitted to ACATS prior to test certification, so preliminary comparisons are possible.

V. Advantages of ATRC System

- o Our "Advanced Digital HDTV" system was officially certified on January 30, 1992 for testing scheduled to begin in May.
- o The system is based on American technology and was developed at America's two largest video R&D labs: The Sarnoff Center in Princeton, NJ, and Philips Labs in Briarcliff, NY.
 - Sarnoff is renowned in the television industry for creating color TV in the 1950's and for developing the current NTSC broadcast transmission standard.
 - Philips created compact disc technology and numerous other audio/video advancements.
- o The ATRC system is the most advanced when measured by the FCC's own criteria, and it contains the most innovative use of digital technology. It is truly the high-quality option for America.

- o Superior HDTV Picture and Sound Quality: Advanced Digital HDTV uses a high 24 million bits per second data rate to achieve superior HDTV picture and CD-like sound quality.
 - o Lowest Interference with Existing NTSC Service: The system's unique spectrally-shaped signal uses the simple and effective approach of avoiding the high-power portions of an NTSC signal to simultaneously achieve low interference into existing NTSC service areas and high immunity from NTSC interference.
 - o Highly Reliable and Robust Performance for Broadcasting: The ATRC system transmits its sound and "viewable picture" data on a higher-power carrier, separate from NTSC, providing a highly reliable and robust broadcast signal.
 - o Coverage Area Better Than or Equal to NTSC and High Accommodation: The higher-power carrier in the spectrally-shaped signal allows for increased simulcast transmission power and reduced co-channel spacing needed to provide outstanding coverage area and to accommodate broadcasters with a simulcast channel.
- Our system fits on 6 Mhz., meaning no need for FCC spectrum reallocation.

- o Most Flexible Scope of Services: The system's unique data format and flexible operating characteristics allow for an unsurpassed scope of services, which will generate new forms of educational and entertainment programming as well as extraordinary interactive use of the home TV set.
- o Greater Interoperability and Extensibility for Future Growth: The ATRC system is the only one of the proposed digital systems that is compatible with MPEG, the international digital video and audio standard. Thus, the system includes interoperability features which make it multimedia ready and compatible with the consumer electronics, telecommunications and computer industries around the world.
 - This is a state-of-the-art feature vital to the future of HDTV in America.
 - Thus, the ATRC system is best positioned to facilitate the development of new video services and to support the emerging relationship between computers and television.
- o Lower Cost for Broadcasters, Alternative Media and Consumers: The system leverages the MPEG standard to achieve the most powerful economy of all: a single video compression standard for all consumer, computer and broadcast equipment, which will eliminate the need for multiple encoder and decoder types and create important synergies and economies of scale.

In short, the ATRC system combines cutting-edge technology with emerging worldwide standards.

And the Sarnoff-NBC-Philips-Thomson-CLI consortium alone has the U.S. manufacturing presence and broadcaster support to implement the standard as effectively and as quickly as possible.

VI. The ATRC Option: More U.S. Jobs

- o The consortium's HDTV development program is backed by a rapidly emerging implementation program.
- o Thomson and Philips are the two leading TV manufacturers in the United States both in terms of U.S. jobs and TV sets produced:
 - 19,000 workers at 10 plants in 6 states;
 - Thomson (RCA, GE, ProScan) and Philips (Magnavox, Sylvania, Philco, Philips) brands account for more than one-third of all TV receivers purchased by American consumers.

- o Thomson, headquartered in Indianapolis, IN, recently announced plans to manufacture its widescreen HDTV receivers at its Bloomington plant -- the largest TV assembly plant in the world. Large glass and picture tubes will be made at Thomson's newly-upgraded Circleville, OH, and Marion, IN plants, respectively (\$160 million already spent to modernize).
 - Thomson alone employs more than 9,000 workers at its manufacturing, R&D and distribution facilities in the United States.
 - Its other plants and facilities are located in Scranton and Lancaster, PA; Mocksville, NC; and Syracuse, NY.
- o Philips Consumer Electronics Company and Philips Laboratories are divisions of North American Philips Corp., a Fortune 100 company headquartered in NY with 43,000 U.S. employees and over \$6 billion of U.S. sales annually.
 - Philips Consumer Electronics is headquartered in Knoxville, TN and has manufacturing operations in Greenville and Jefferson City, TN, and Arden, NC. Philips makes its picture tubes in Ottawa, OH.
 - Philips Labs in Briarcliff Manor, NY has 350 scientists and engineers.

- Philips' Magnavox CATV Systems, Inc. is headquartered in Manlius, NY and manufactures broadband distribution equipment for the cable television industry.
 - Philips has 10,000 people employed in its TV-related business.
- o Sarnoff employs 725 U.S. researchers, scientists, engineers and other personnel.
- o Compression Labs, based in San Jose, California, is planning for the design and manufacture of transmission encoders for the ATRC system.
- o NBC, along with its 208 affiliate stations, is evaluating program production and transmission requirements for the broadcast networks as well as local over-the-air stations.